B-3—Sensitivity Analysis for Model Simulating the Gunlock Part of the Navajo Aquifer

The baseline model for the Gunlock part of the Navajo and Kayenta aquifers was tested to determine sensitivity of simulation results to variation in properties and fluxes within what is considered a reasonable range. The parameters varied were (1) hydraulic-conductivity values for each of the simulated aquifers (the Navajo and Kayenta aquifers); (2) vertical hydraulic-conductance values between the two aquifers; (3) streambed conductivity of model cells simulating the Santa Clara River; (4) anisotropy; (5) amount of areal recharge as infiltration of precipitation, and (6) infiltration of water from Gunlock Reservoir.

Simulated water levels in the model domain are sensitive to changes in horizontal hydraulic-conductivity values of both the Navajo and Kayenta aquifers. Decreasing the hydraulic conductivity of the Navajo aquifer by 0.5 caused calculated water levels to rise an average of almost 50 ft in both the Navajo and Kayenta aquifers (fig. B3-1). The same decrease in the conductivity of the Kayenta aquifer caused average water-level rises of about 25 ft (fig. B3-3). Increases in hydraulic-conductivity values caused an average water-level decline of as much as 100 ft. These effects are not the same near St. George city municipal well field., where decreasing hydraulic-conductivity values caused a general decline in water levels, and increased hydraulic-conductivity values caused water-level rises. This is a localized effect caused by the simulated ground-water withdrawals. When the hydraulic-conductivity value of the Navajo aquifer was reduced to 0.1 of the baseline value, the model simulated complete dewatering at several cells where withdrawals are simulated. The head-dependent flux into and out of the ground-water system from the Santa Clara River was moderately sensitive to increases in hydraulic conductivity (figs. B3-2 and 4). The Santa Clara River is the only head-dependent boundary in the simulation, and mass balance within the model domain is maintained by flux across this boundary. Therefore, when simulated inflow to the ground-water system increases, a corresponding increase in outflow also will be simulated. Simulated water levels and fluxes were largely insensitive to changes in the vertical conductance between the Navajo and Kayenta aquifers (figs. B3-5 and 6).

Decreasing the hydraulic conductivity of the Santa Clara River streambed by one order of magnitude caused calculated water levels to decline substantially from baseline levels (fig. B3-7). As discussed previously, mass balance in the model domain is maintained by flux across the mathematical boundary that simulate the river. The minimum inflow that must be simulated from the Santa Clara River is equal to the difference between the amount of recharge specified from precipitation and from Gunlock Reservoir, and the average discharge simulated at the St. George city municipal well field. When streambed conductivity was reduced, large calculated water-level declines were required to maintain that minimum inflow. Simulated water levels were largely insensitive to increases in streambed hydraulic conductivity. Simulated fluxes to and from the Santa Clara River were sensitive to changes in streambed conductivity (fig. B3-8). Inflow in the model that exceeds the minimum is recirculated back to the lower reaches of the Santa Clara River.

Simulated water-levels were quite sensitive to changes in anisotropy; simulated fluxes varied only slightly (figs. B3-9 and 10). Removing the effects of anisotropy (anisotropy equals 1) caused calculated heads to increase an average of about 100 feet; at the St. George city municipal well field, however, calculated water levels declined. When effective conductivity of the model domain is reduced, the hydraulic gradient and saturated thickness of the Navajo aquifer needs to be increased to simulate the same amount of ground-water flow through the system. A similar effect is seen when specified recharge from precipitation or from Gunlock Reservoir is changed (figs. B3-11, and 13). When recharge amounts decrease, water levels decline and the resulting hydraulic gradient is decreased. When recharge is increased, gradients and the saturated thickness of the Navajo aquifer increase to compensate the additional flow of ground water from recharge areas to the St. George municipal well field and the Santa Clara River. Net flux to the Santa Clara River equates directly to the amount of change in the specified flux from precipitation and from Gunlock Reservoir (figs. B3-12 and 14).

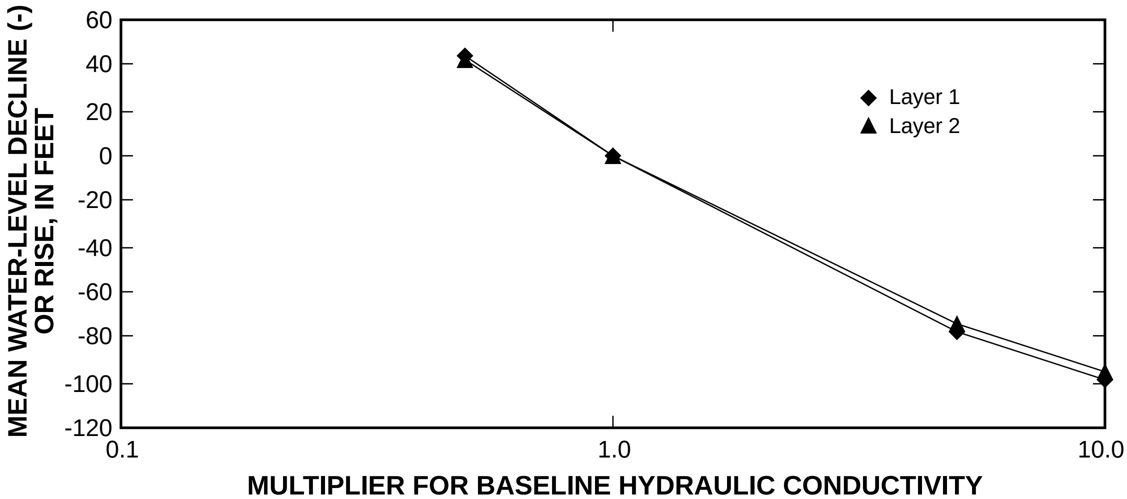

Figure B3-1. Sensitivity of water level to variations in the horizontal hydraulic conductivity of the Navajo aquifer in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

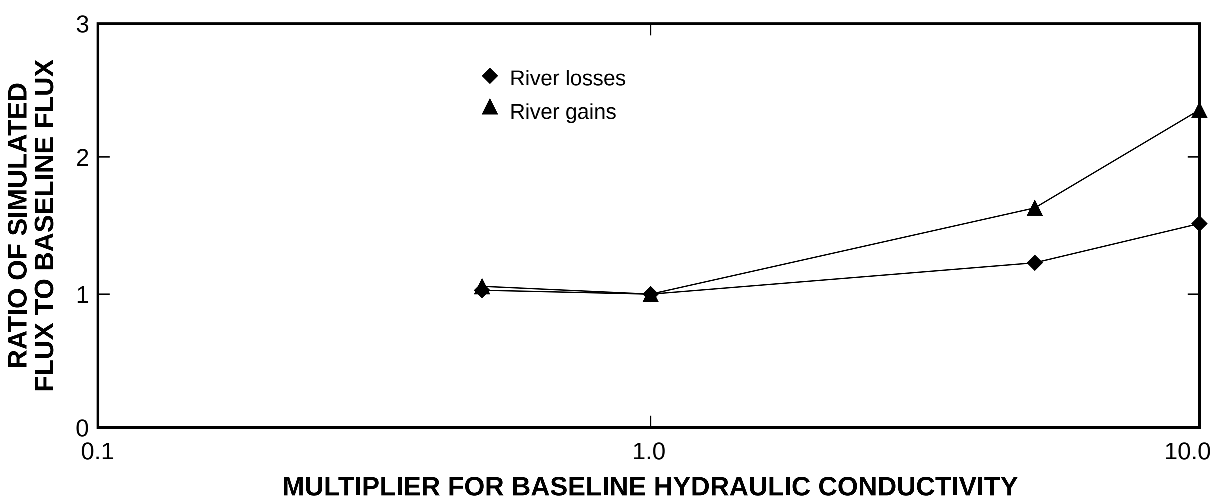

Figure B3-2. Sensitivity of simulated flux to and from the Santa Clara River to variations in horizontal hydraulic conductivity of the Navajo Sandstone aquifer in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

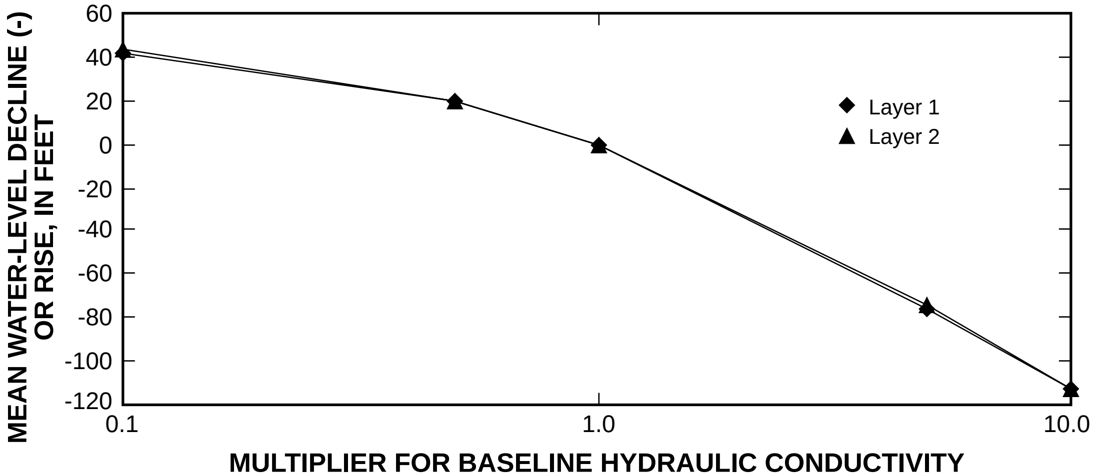

Figure B3-3. Sensitivity of water level to variations in the horizontal hydraulic conductivity of the Kayenta aquifer in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

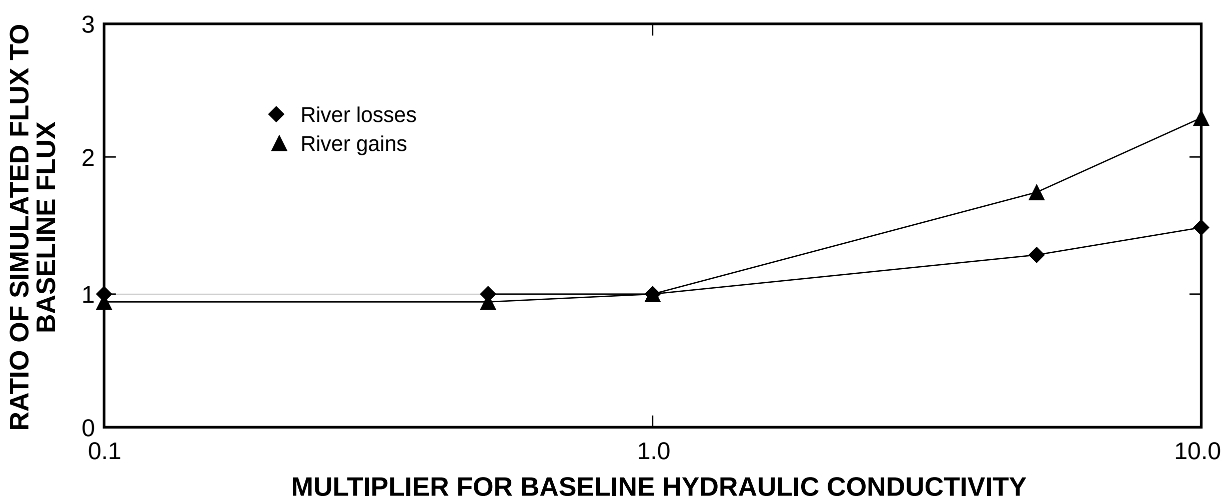

Figure B3-4. Sensitivity of simulated flux to and from the Santa Clara River to variations in horizontal hydraulic conductivity of the Kayenta aquifer in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

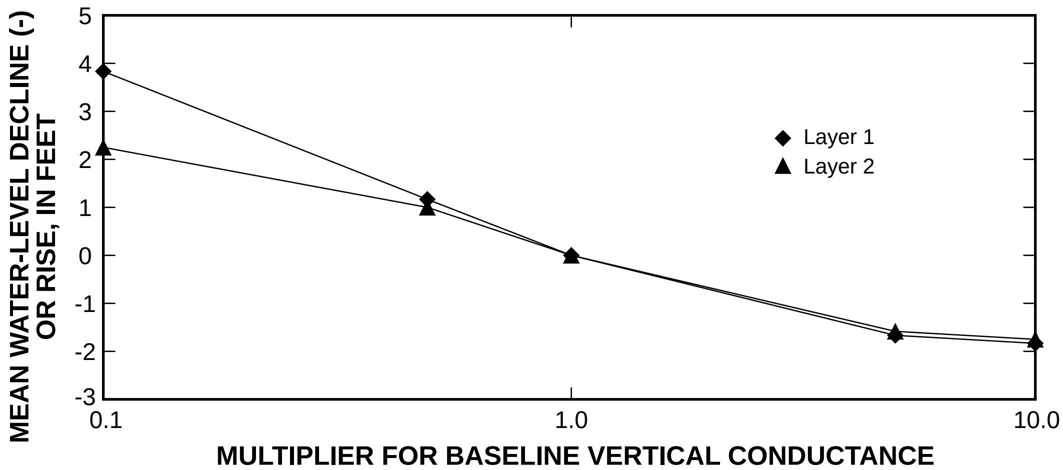

Figure B3-5. Sensitivity of water level to variations in the vertical conductance between the Navajo and Kayenta aquifers in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

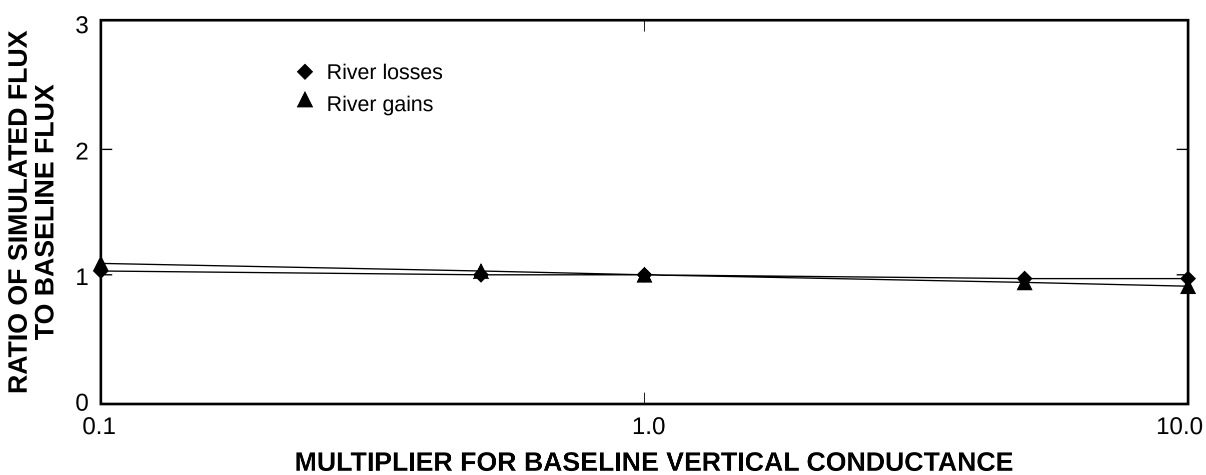

Figure B3-6. Sensitivity of simulated flux to and from the Santa Clara River to variations in vertical conductance between the Navajo and Kayenta aquifers in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

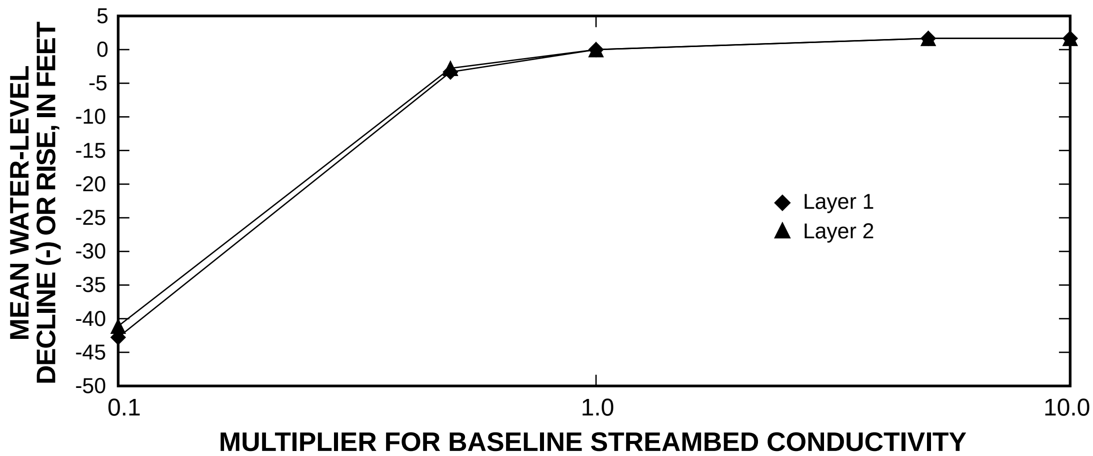

Figure B3-7. Sensitivity of water level to variations in streambed conductance in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

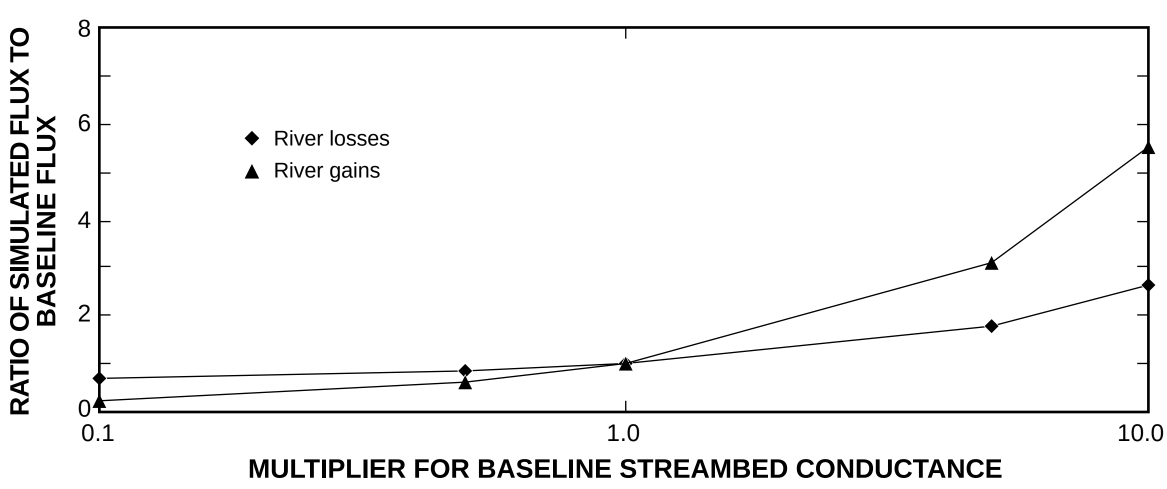

Figure B3-8. Sensitivity of simulated flux to and from the Santa Clara River to variations in streambed conductance in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

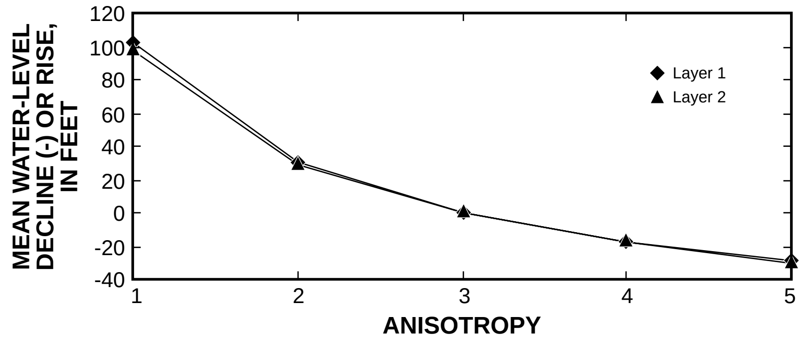

Figure B3-9. Sensitivity of water level to variations in anisotropy in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

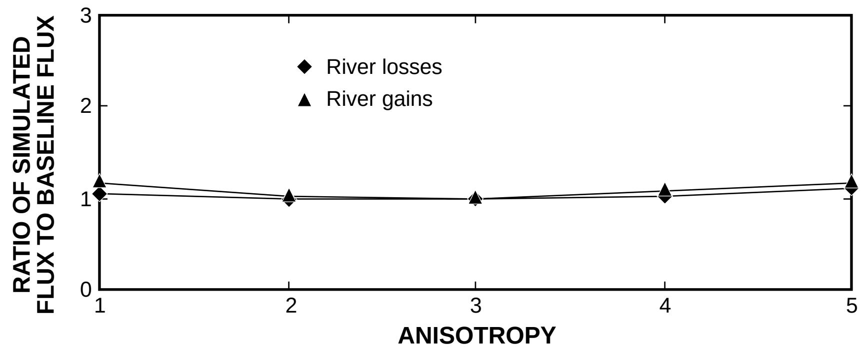

Figure B3-10. Sensitivity of simulated flux to and from the Santa Clara River to variations in anisotropy in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

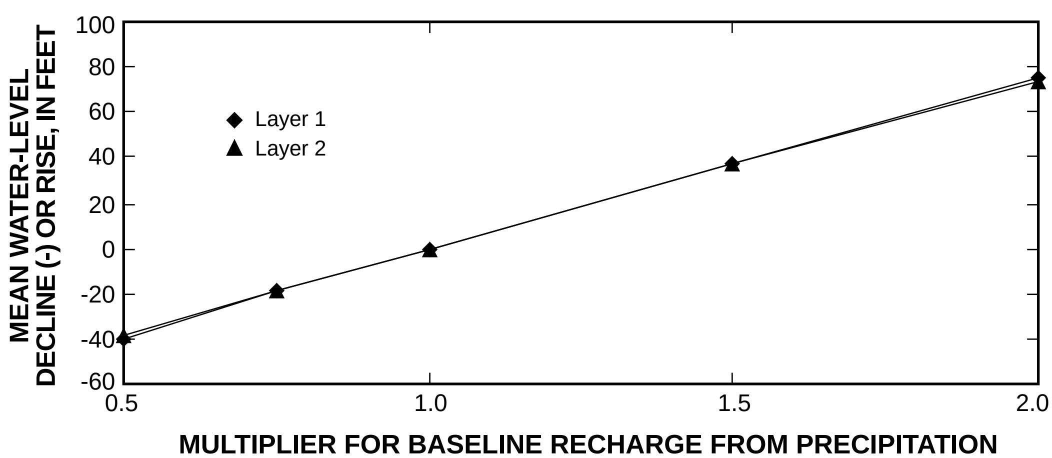

Figure B3-11. Sensitivity of water level to variations in recharge from precipitation in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

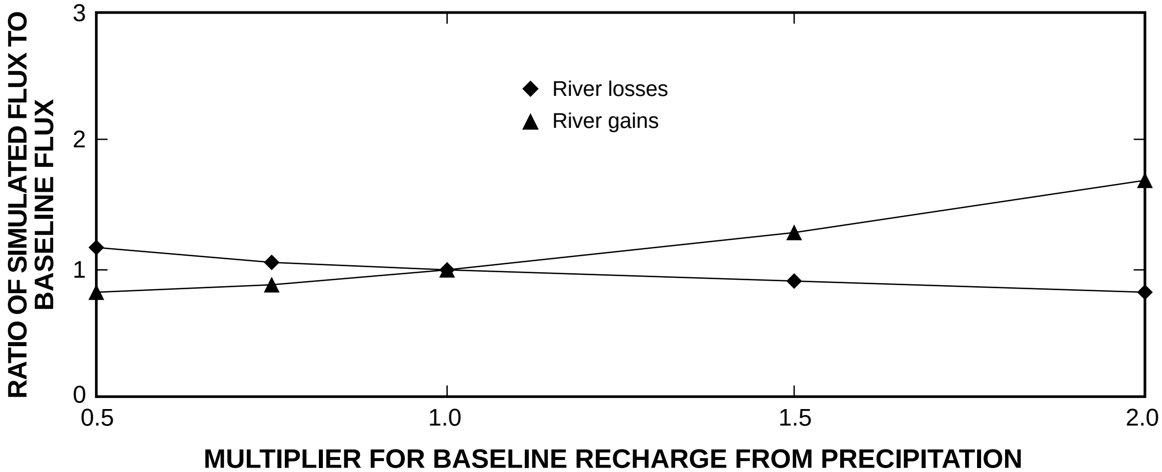

Figure B3-12. Sensitivity of simulated flux to and from the Santa Clara River to variations in recharge from precipitation in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

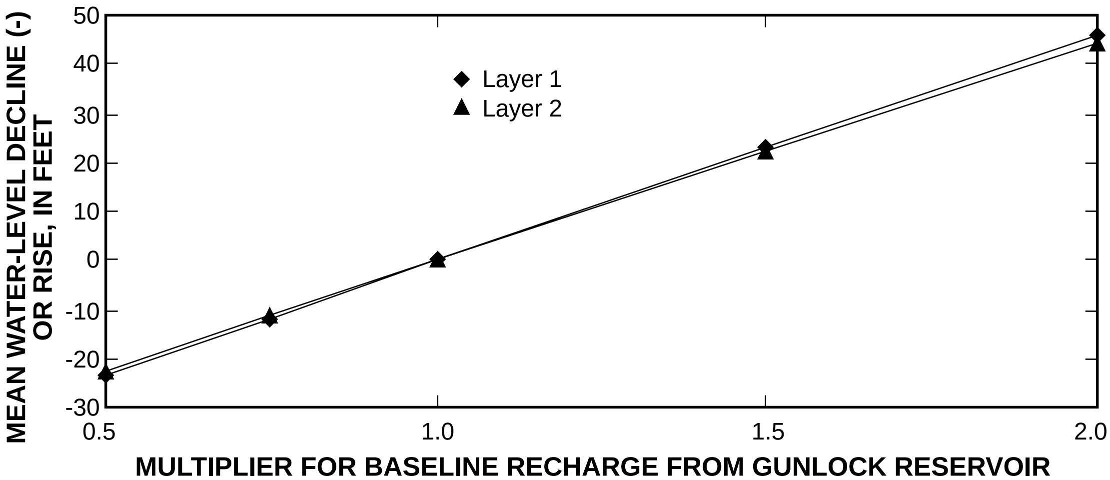

Figure B3-13. Sensitivity of water level to variations in recharge from the Gunlock Reservoir in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.

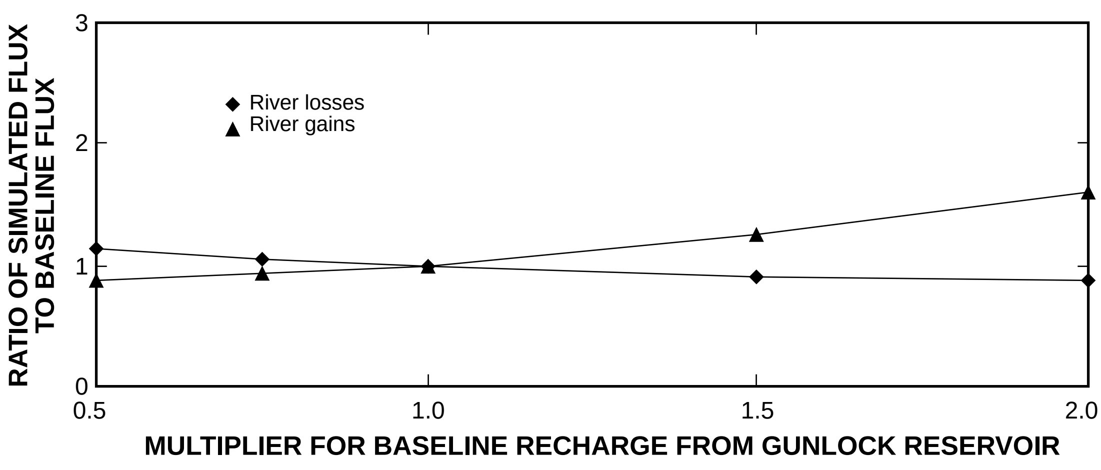

Figure B3-14. Sensitivity of simulated flux to and from the Santa Clara River to variations in recharge from the Gunlock Reservoir in the ground-water flow model of the Gunlock part of the Navajo and Kayenta aquifers within the central Virgin River basin study area, Utah.